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Multiple sulphur isotope analysis of detrital pyrite as a tool for provenance analysis in Archaean sedimentary rocks

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Multiple S isotope analysis allows to distinguish between S that passed through the photochemically active Archaean atmosphere and magmatic S incorporated into hydrothermal fluids. Furthermore, sulphides and associated barites present in VMS deposits and BIFs that formed by seawater circulation through hydrothermal systems and seawater sulphate reduction commonly carry negative Δ^{33}S values in contrast to sulphides in Archaean black shales that formed away from hydrothermal circulation that generally have positive Δ^{33}S values.

Rounded grains of pyrite are a common component of Archaean conglomerate-hosted gold and uranium deposits of the Witwatersrand type. Most workers regard rounded pyrite grains to be detrital in origin, although post-depositional replacement of iron oxides by pyrite has also been proposed. The presence of detrital pyrite has important implications for the oxygen level in the Archaean atmosphere, while the relationship between pyrite and gold in conglomerate reefs may indicate a common provenance for both pyrite and gold.

We have carried out multiple S isotope analysis of rounded pyrite grains from several Archaean conglomerates. The c. 2.6 Ga Cheshire Formation of the Belingwe greenstone belt in Zimbabwe is a sedimentary sequence derived predominantly from erosion of underlying strata, which include mafic and ultramafic volcanic rocks and a sedimentary sequence (Manjeri Formation) that contains black shale-hosted sedimentary and, at the top, volcanogenic massive sulphides. Rounded pyrites from a Cheshire Formation conglomerate sample show a large range in S isotope values (δ^{34}S = -12.8 to -1.1 ‰ V-CDT, Δ^{33}S = -0.9 to -0.2 ‰) that are identical to massive sulphides of the Manjeri Formation that were likely present in the provenance of this unit.

The provenance of rounded pyrite in gold-bearing conglomerates (reefs) in South Africa is unknown and a matter of continuing debate. Pyrites from the c. 2.9 Ga Mozaan Contact Reef of the Pongola Supergroup show a very small range in S isotope values (δ^{34}S = 0.3 to 2.8 ‰ V-CDT, Δ^{33}S = 0.1 to 0.2 ‰), which is consistent with a provenance from granitoid-greenstone hosted hydrothermal sulphide-quartz veins. In contrast, pyrites from the c. 2.6 Ga Black Reef of the Transvaal Supergroup show values typical of photochemically-processed S in the atmosphere (δ^{34}S = -5.6 to 9.1 ‰, Δ^{33}S = -1.4 to 0.2 ‰). Rounded pyrites from the 2.85 Ga Kimberley Reef of the Witwatersrand Supergroup and the 2.7 Ga Ventersdorp Contact Reef show similar values for δ^{34}S (-0.2 to 10.7 ‰) and Δ^{33}S (-0.5 to 0.1 ‰), indicating derivation from a sedimentary source.

Our data indicate a detrital origin for the rounded pyrites in the conglomerates investigated. It further shows that multiple S isotope analysis is a powerful tool in the provenance analysis of detrital pyrite. Our study will place tighter constraints on the source of gold for Witwatersrand-type deposits, which has so far remained elusive.